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PITCH DAMPING TESTS OF THE PERSHING RE-ENTRY BODY (U)

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Aerodynamics Research Report 110

PITCH DAMPING TESTS OF THE PERSHING RE-ENTRY BODY

Prepared by

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ABSTRACT: This report presents the results of an investigation in the NOL Supersonic Tunnel No. 1 to measure the pitch damping of the Pershing re-entry body.

These data were obtained at Mach numbers 1.76, 2.03, 2.28, 2.76, 3.51, 4.12, and 4.82.

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The purpose of this investigation was to obtain pitch damping data on the Pershing re-entry body. This investigation was performed at the request of Army Ballistic Missile Agency (reference (a)), under Task Number NOL 455.

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PITCH DAMPING TESTS OF THE PERSHING RE-ENTRY BODY

INTRODUCTION

1. The Pershing missile is a medium range ballistic missile being developed by the Army Ballistic Missile Agency.
2. This report gives the results of a wind-tunnel investigation performed to determine the pitch damping of the re-entry body.

AERODYNAMIC SYMBOLS

A	reference cross-sectional area (sq. in)
$C_{M_q} + C_{M_{\dot{\alpha}}}$	aerodynamic damping coefficient ($-16\mu/\pi\rho Vd^4$)
c.g.	center of gravity (2.5493 reference diameters from the base)
d	reference diameter (one caliber) (2.25 inches)
Ma	Mach number
I	transverse moment of inertia about the c.g. (slugs-ft ²)
t	time (sec)
V	velocity (ft/sec)
$\bar{\alpha}$	average angular amplitude (deg)
α	angle of attack (deg)
α_t	trim angle (deg)
ρ	air density (slugs/cu.ft)
μ	dynamic damping coefficient ($-2I n\alpha/\alpha_o/\Delta t$)

DESCRIPTION OF THE MODELS AND TEST TECHNIQUE

3. The model was dynamically balanced about the scaled full-scale center of gravity. A shaft whose axis was normal to the longitudinal axis of the model was passed through the center of gravity and was attached to the model by means of precision ball bearings of very low frictional torque. The model was thus able to rotate in the pitch plane about a transverse axis. The model was mounted in the wind tunnel and started to rotating before the wind tunnel was started. The rotating motion of the model becomes an oscillating one when the wind tunnel begins blowing. The model oscillations begin to damp. This motion of the model is recorded with a high-speed motion-picture camera with a film speed of 75 frames per second.

Figure 1 shows a sketch of the model.

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DATA REDUCTION

4. The evaluation technique is described in detail in reference (b). Briefly the data reduction consists of two phases: reading the film and fitting an envelope to the data obtained from the film. From the film the angle of attack of the model is obtained for each frame of film using a comparator. The time record is obtained from the film speed. The angular deflection plotted against time yields a damped sine motion. The envelope of the motion is faired. Damped harmonic motion requires that the restoring moment be linear; this is not always the case. However, by assuming the harmonic condition for small increments along the envelope, the damping coefficient can be obtained as a function of average angular deflection.

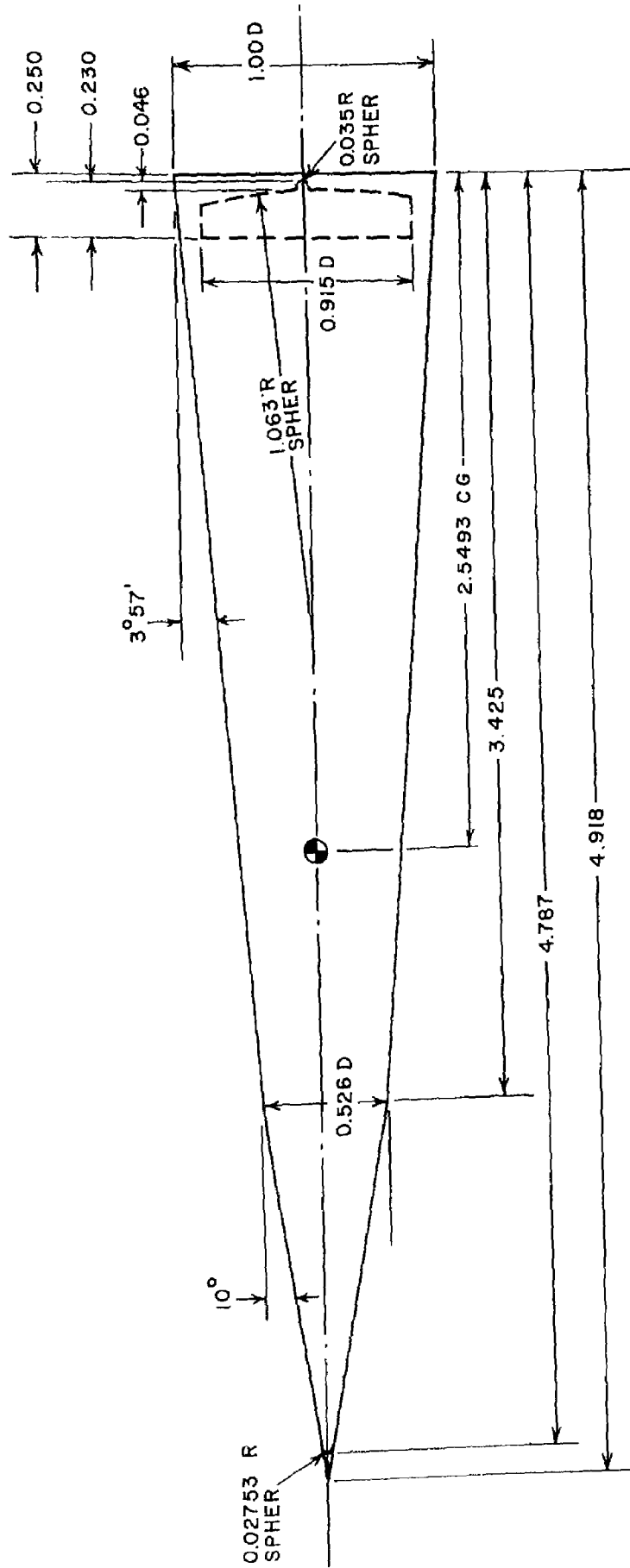
DISCUSSION

5. The data are plotted as $C_{M_q} + C_{M_{\dot{\alpha}}}$ versus $\bar{\alpha}$ in Figures 2 through 5. At Mach numbers 1.76 and 2.03 small trim angles were noted.

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REFERENCES

- (a) Geissler, E. D., Wind-Tunnel Request (WTR-581) 1960
- (b) Shantz, I., and Groves, R. T., "Subsonic Damping-in-Pitch Measurements of the EX-10, EX-30, and 6" Test Vehicle," NAVORD Report 4025, Conf., (1958)



ALL DIMENSIONS IN CALIBERS

FIG. 1 PERSHING RE-ENTRY BODY

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 PERSHING
 $C_{M_q} + C_{M_{\dot{\alpha}}}$ vs $\dot{\alpha}$

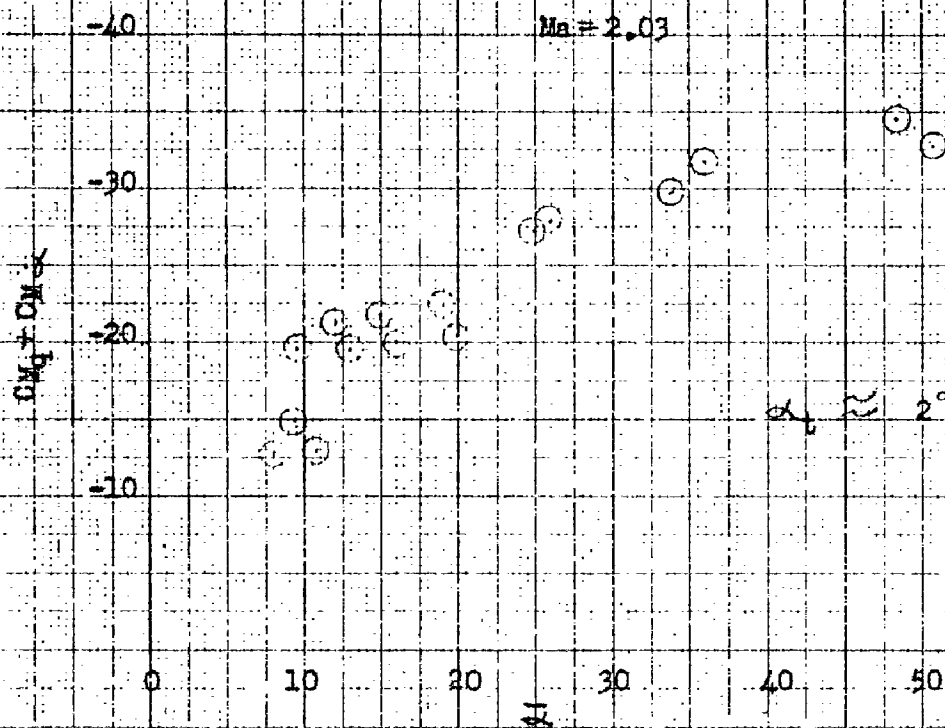
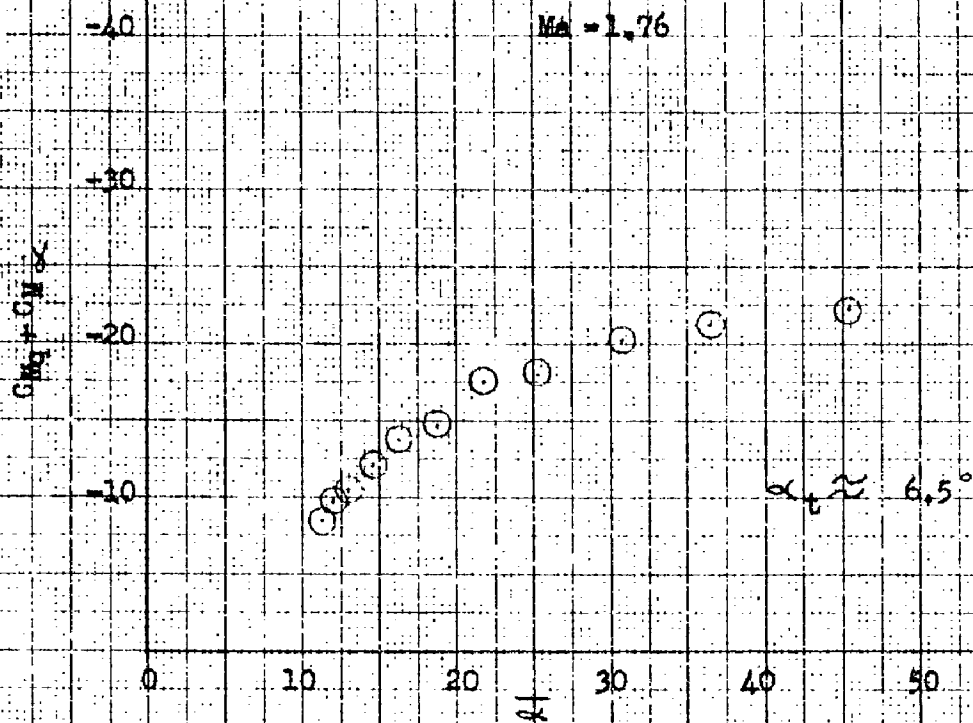


FIG. 2 $C_{M_q} + C_{M_{\dot{\alpha}}}$ versus $\dot{\alpha}$

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$C_{M_q} + C_{M_{\dot{\alpha}}}$ vs $\frac{1}{\alpha}$

$Ma = 2.28$

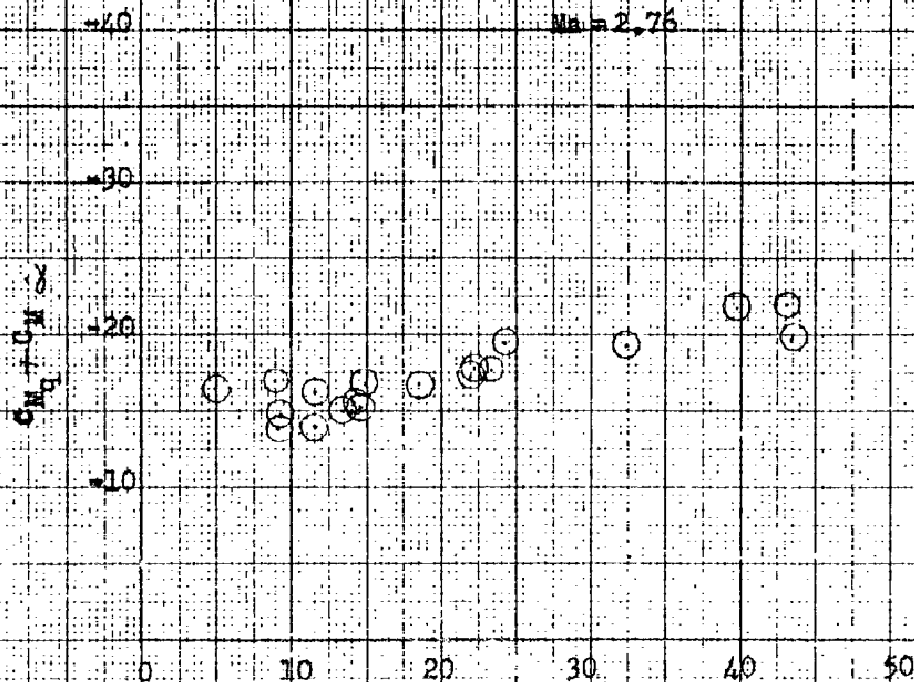
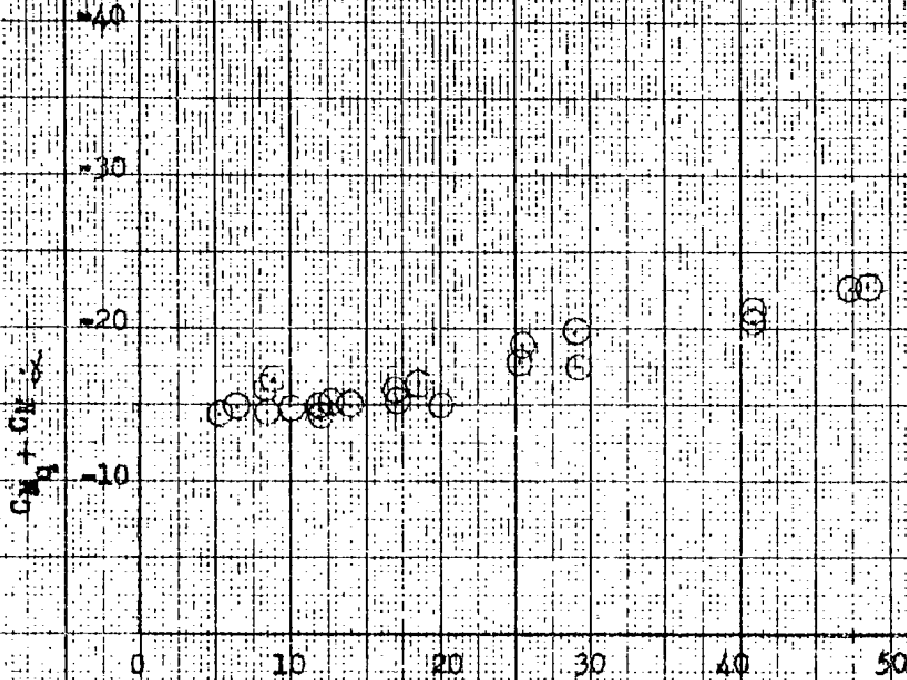


FIG. 3 $C_{M_q} + C_{M_{\dot{\alpha}}}$ versus $\frac{1}{\alpha}$

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$C_{M_q} = 0$ vs Re

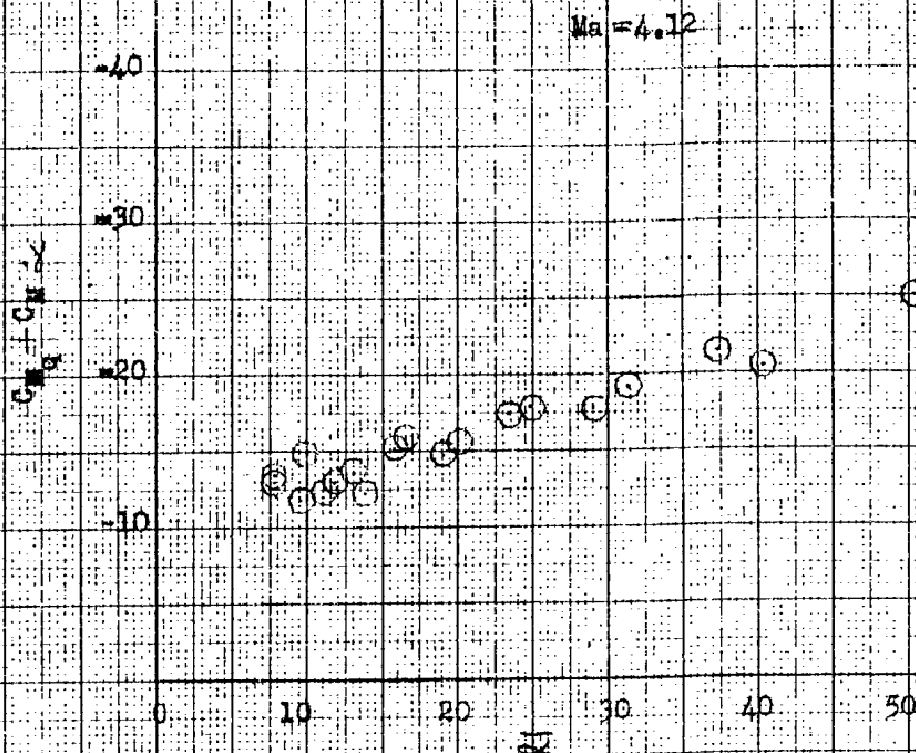
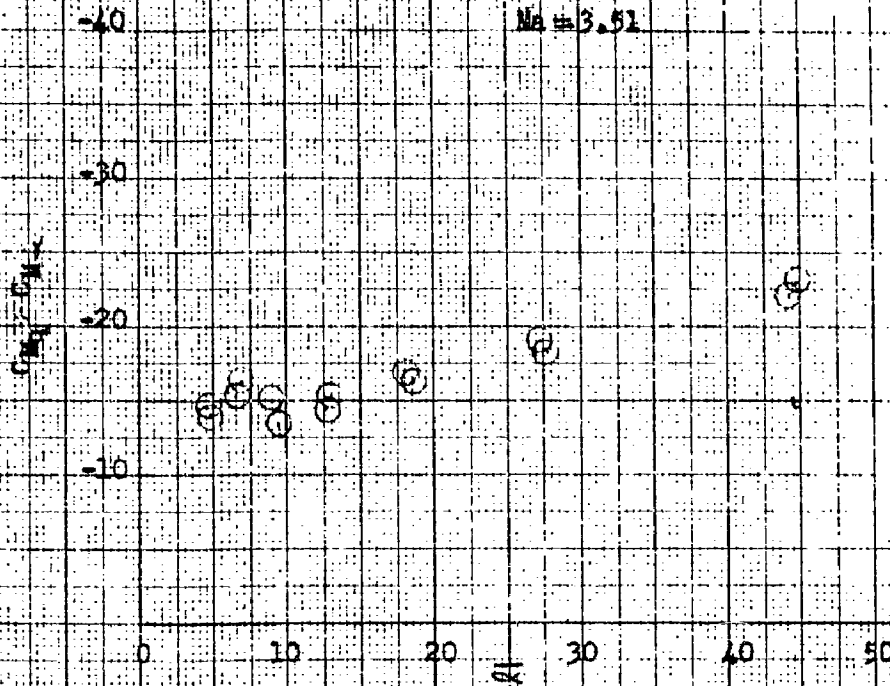


FIG. 4 $C_{M_q} + C_{M_d}$ versus

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PERMING

$$C_{M_q} + C_{M_{\dot{\alpha}}} \text{ versus } \alpha$$

$$Ma = 3.51$$



$$Ma = 4.82$$

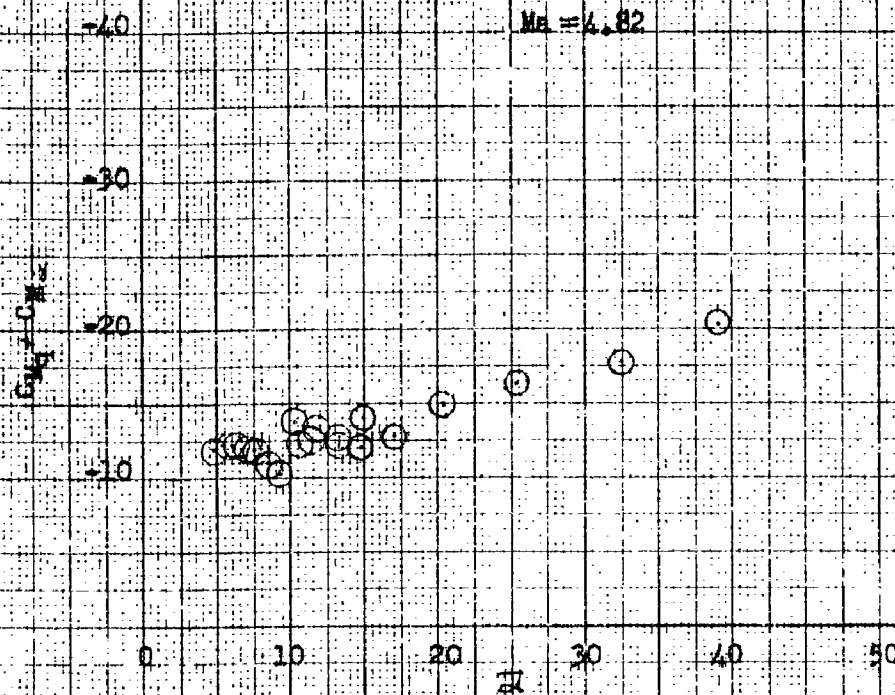


FIG. 5 $C_{M_q} + C_{M_{\dot{\alpha}}}$ versus α

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